General Motors North America
Engineering Analysis

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Mrs. Mary Quinn Cooper, Esq.
McAfee & Taft
1717 S. Boulder, Suite 900
Tulsa, OK 74119

Expert Report of Kathryn F. Anderson
Richard Faust, as the Personal Representative of the Estate of K.F.,
Ashley Faust, individually, and Justin Frederick, individually
v. General Motors, LLC, Autoliv ASP, Inc., and Delphi Automotive, LLC

Dear Mrs. Cooper:

INTRODUCTION

This report contains my assessment of the design, development, and performance of the restraints systems in the subject vehicle, a 2012 Chevrolet Malibu sedan (VIN 1G1ZD5EU0CF383419), as well as the restraint system performance during the subject crash that occurred on March 17, 2014. This report also addresses the history and evolution of air bags, and sensing system technology. Ms. Ashley Faust was driving the subject vehicle at the time of the crash, and her daughter, K.F. was riding in the right front passenger seat.

QUALIFICATIONS

I have a Bachelor of Science degree in Engineering from Purdue University. The focus of my undergraduate studies was in biomedical engineering through the Interdisciplinary Engineering school at Purdue University. I also have a Master of Science degree in Biomedical Engineering (Biomechanics) from the University of Michigan.

I have been employed by General Motors since 1991, and am currently a Senior Technical Consultant and GM Technical Fellow – Occupant Protection and Biomechanics in the Engineering Analysis group within our Global Vehicle Safety organization. In the past, I have been responsible for the development of front and rear seat occupant protection systems and have conducted crash and sled tests to assess the performance of these systems. I have also been responsible for the design release of driver air bags, passenger air bags, and steering wheels. I have knowledge and experience in the development, testing, and design of the components that comprise a frontal impact restraint system. I am also familiar with the design, development, and testing of the General Motors GMX386 product lines and will testify about this if asked.

Figure 3 – Police Photo Taken of Passenger (Right) Side of Subject Vehicle at the Crash Scene

Figure 4 – Police Photo Taken of Driver's (Left) Side of Subject Vehicle at the Crash Scene

Upon his arrival on scene, Officer Scruggs was advised that both the driver and right front passenger had been transported in critical and unstable condition to Oklahoma University (OU) Medical Center.

REPORTED INJURIES

K.F., the right front passenger, was fatally injured as a result of the above-mentioned crash event. K.F. was 11 years old, and reportedly 148 cm (4'10") tall and weighed 47.1 kg (103.62 lbs.) on 3/10/2014, seven days prior to the crash event (per OUCP Medical Records of an office visit at the OUCP Sooner Pediatric Clinic with Dr. Geoffrey Lowe). Based on a review of the documents listed above, it was reported that K.F. was found belted in the right front passenger seat, and was unresponsive at the scene. She had reportedly vomited prior to EMS arrival, and vomited again after she was removed from the vehicle. EMS personnel noted that she had swelling to the left side of her face, blood coming from her right ear, and had an increased rate of shallow breathing (tachypnea). It was also reported that she had soft tissue swelling and bruising of her right lower abdomen, and abrasions on her right hip. Upon EMS arrival at the scene, K.F. had a Glasgow Coma Score of 6 with dilated pupils (non-reactive right pupil, and sluggish response from left pupil). She was transported by ground ambulance to OU Medical Center, and exhibited signs of decorticate posturing while enroute. K.F. was pronounced dead three days after the subject crash, on March 20, 2014, and her immediate cause of death, as reported by Medical Examiner, Dr. Chai Choi, was head and neck injuries due to blunt force trauma.

The frontal air bag system in the 2012 Chevrolet Malibu primarily consists of the driver and passenger frontal air bag modules, two electronic front sensors (EFSs), and the electronic sensing and diagnostic module (SDM). The EFSs are located on the front of the vehicle on the upper radiator tie bar. The SDM module is mounted on the center tunnel, under the center console between the driver's and right front passenger's seats. The SDM is an onboard electronic module which functions to continuously monitor the air bag system in the car while the ignition is on, to deploy the air bags, and to record certain crash and air bag system data in deployment and non-deployment level crash events. The SDM also functions as an energy reserve for air bag deployment should a vehicle lose power during an accident. The SDM diagnoses and detects air bag system malfunctions, and notifies the driver of any malfunction by illuminating the SIR warning lamp. Information about a malfunction in the air bag system will be stored as a fault code in the SDM's memory.

The SDM in the 2012 Chevrolet Malibu senses vehicle decelerations in the longitudinal and lateral directions. In frontal or near frontal impacts, the occupant's motion will be primarily forward into the seat belt and frontal air bag. In order for the frontal air bags to deploy, the vehicle must exceed a pre-determined deployment threshold. This threshold will be exceeded when the SDM experiences a sufficient level of longitudinal deceleration to warrant the deployment of the frontal air bags for supplemental protection. When the SDM detects a deployment level crash, it will deploy the frontal air bags and create a permanent "deployment event" record. This record is written to non-volatile memory, and therefore the deployment event is not erased from the SDM's memory, and the SDM will not overwrite the data or clear the data.

According to information in the Official Oklahoma Traffic Collision Report, Officer Scruggs and Msgt. Atkins removed the air bag sensing and diagnostic module (SDM) from the subject vehicle at 4A Wrecker Service, the day after the crash event. They did a direct download of the SDM module (out of the vehicle), with the CDR tool in their office on March 18, 2014, to obtain the crash event data. The SDM contained a complete deployment event record, which corresponded to the subject incident described above. The sensing and diagnostic module (SDM) was downloaded at ignition cycle 3761, and contained a deployment event file from ignition cycle 3761. This data file indicates that the SDM sensed the impact with the tree as an above-threshold level frontal impact and commanded deployment of the driver and right front passenger seat belt pretensioners, and the first and second stages of the driver's frontal air bag in response to the subject crash. The passenger's frontal air bag was suppressed and was not commanded to deploy, based

on a valid input received by the SDM from the right front passenger's occupant classification sensing system. The crash event data indicated that the air bag warning lamp was off prior to the recorded crash event, indicating the air bag system was functioning properly at the time of the crash. The SDM had also recorded the driver's and right front passenger's seat belt statuses as buckled at the time of the crash event, which is consistent with the police officers reporting that both Ashley and K.F. were belted during the crash event.

During my inspection of the interior occupant compartment, I noted that both the driver and right front passenger seat belt pretensioners, and the driver's frontal air bag were deployed. The right front passenger frontal air bag was not deployed. The driver's and right front passenger's seat belts had been cut, and there was evidence of occupant loading on both of the seat belt guide loops (reference Figures 10 and 11).

Figure 10 – Anderson Inspection Photo, fau_251kfa

Figure 11 – Anderson Inspection Photo, fau_252kfa

The average accelerations for each of these tests and the subject vehicle, from the time of deployment to when the vehicle reached its maximum longitudinal velocity are shown in Table 1 below. The higher the average acceleration is, the greater the severity of the crash. Because of the high speed at which Ms. Faust impacted the tree, there was a significant amount of energy that had to be absorbed by the deformation of the vehicle structure and absorbed by the occupant restraints systems.

	40 mph, 40% Left Offset, Deformable Barrier C15674	**35 mph, 0 deg Frontal, Rigid Barrier C17318**	**30 mph, Rigid Pole Impact C14109**	**30 mph, 0 deg Frontal, Rigid Barrier Sled Pulse S20698**	**30 mph, 125 msec, FMVSS 208 Sled Pulse S20708**	**59 mph Rigid Tree Impact, Subject Vehicle Crash**
Change in Velocity from Time of Deploy to Time of Max Longitudinal Velocity (mph)	40.67 mph	40.11 mph	31.28 mph	35.13 mph	29.85 mph	50.15 mph
Time from Deploy to Max Longitudinal Velocity (msec)	121 msec	88 msec	93 msec	88 msec	103 msec	60 msec
AVERAGE ACCELERATION (g's)	**15.3 g's**	**20.8 g's**	**15.3 g's**	**18.2 g's**	**13.2 g's**	**38.1 g's**

Table 1 - Average Vehicle Accelerations from Time of Deployment to Time of Maximum Longitudinal Velocity

Mr. Jon Bready calculated the peak resultant change in velocity experienced by the subject vehicle during the frontal impact with the tree to be 66.86 mph, and estimated the principal direction of force (PDOF) applied to the subject vehicle was approximately 11 degrees toward the driver's side. Mr. Bready also determined that the subject vehicle was at an approximate 18 degree roll angle (toward the driver's side) when it hit the 12"-14" diameter tree due to the downward pitch of the ditch. This orientation of the vehicle when it impacted the tree, would cause the occupants in the subject vehicle to move forward and toward the left, relative to the vehicle's interior. K.F. was reportedly 4'10" tall and approximately 103.62 lbs. at the time of the accident, and would have moved forward and to her left during the frontal impact. These occupant kinematics are consistent with the evidence of occupant loading by K.F.'s knees on the far lower left side of the right front passenger's lower instrument panel and glove box compartment, and the evidence of occupant interaction with the instrument panel center stack components.

It is my understanding that Mr. Bready estimated that the center of the instrument panel, in the area where the radio and HVAC outlets are housed in the center stack, was displaced rearward approximately ten inches when measured statically. It is my opinion that the center of the instrument panel moved rearward greater than ten inches dynamically during the crash event. Due to the high speed, slightly angled, offset impact with the narrow tree, the center of the instrument panel was displaced rearward, but also to the right

relative to the interior as a result of the crush path of the narrow tree (reference Figure 9). I had also observed at my inspection that the center of the instrument panel was displaced rearward and to the right, moving it closer to the right front passenger's seat. The severity of the impact with the tree induced extreme crush of the vehicle and caused the center of the instrument panel to move rearward and to the right, closer to K.F., and the PDOF of the subject crash and her resulting occupant kinematics caused her to move forward, and to the left, increasing her likelihood of injury from contact with the interior.

Looking at weighted 2006-2015 NASS-CDS field data, and injuries sustained by occupants in non-rollover frontal crashes where the total change in velocity (delta V) exceeded 65 mph, it indicated that over 99% of crashes of that severity involved an occupant who sustained an AIS 3 (serious) or greater injury, and over 98% of those crashes of such high severity involved an occupant who suffered a fatal injury (reference Figure 20). Considering K.F.'s fatal injuries, I am of the opinion that the severity of her crash (with a maximum longitudinal change in velocity of more than 65 mph) is certainly a contributor to her higher likelihood of sustaining a fatal injury.

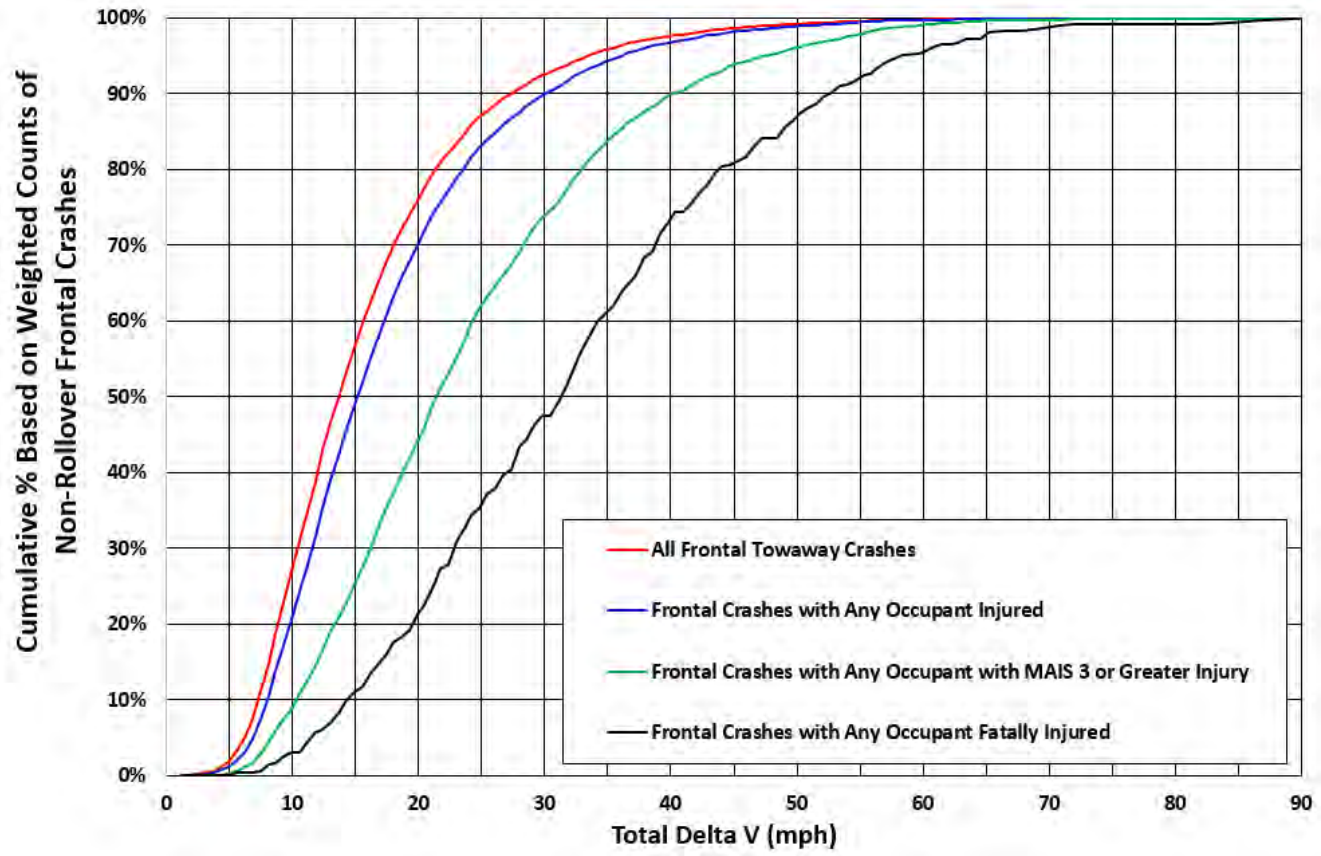

Figure 20 –Cumulative Probability of Injury in Cars and Light Trucks in Non-Rollover Frontal Crashes, 2006-2015 NASS-CDS Data

My opinions are based on my education, my automotive industry experience as a field performance assessment engineer and an occupant protection system development/design engineer and researcher for over 27 years, and my review of the general information outlined above. The investigation into the circumstances surrounding the crash event that occurred March 17, 2014, is ongoing, and my opinions outlined above are based on the information available to me at this time. I reserve the right to amend my opinions should additional information become available to me.

I am a salaried General Motors employee and received no additional compensation for my work on this case. Any publications that I have authored during the last ten years are listed on my CV. If called at trial, I may use any of the items identified above that I reviewed, documents produced in discovery, medical records, and/or documents and items produced by other parties as exhibits to help explain my testimony.

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